BASIC ARCHITECTURE OF THE OVARY IN THE GOLDEN SILK SPIDER, *NEPHILA CLAVATA*

AKIO KONDO, EIKO CHAKI AND MITSUHIRO FUKUDA

Kondo, A., Chaki, E. and Fukuda, M. 1993 11 11: Basic architecture of the ovary in the golden silk spider, *Nephila clavata*. *Memoirs of the Queensland Museum* 33 (2): 565-570. Brisbane. ISSN 0079-8835.

In gravid females of the golden silk spider, *Nephila clavata* L. Koch, the ovaries are composed of flat cisternae. To clarify whether the cisternal structure is primarily or secondarily formed by pressure from mature eggs, ovary development was examined from early subadults to mature spiders. Serial paraffin sections of the early subadults definitely show that a pair of longitudinal furrows, presumptive lumina of the ovaries, lined with loose cell layers, penetrate perpendicularly into the ovarian tissue. So the basic architecture of the ovary in *N. clavata* is primarily flat cisterna.

Im Falle von reifen Weibchen von *Nephila clavata* setzen sich die Ovarien aus flachen Beuteln zusammen. Um herauszufinden, ob diese strukturelle Fläche angeboren ist oder durch den Druck der reifen Eiern gebildet wird, wurde die Entwicklung der Ovarien vom frühen Subadult bis zum reifen Adult untersucht. In den seriellen Paraffinstückchen vom frühen Subadult zeigte sich, daß ein Paar longitudinale Furchen, die mit zerstreuten Zellenschichten verstärkt wurden, d.h. die präsumptive Lumen, perpendikular in die Ovariumgewebe gehen. Daraus kann man schließen, daß die Grundarchitektur von diesen Ovarien angeboren aus flachen Beuteln besteht. □*Spider, Nephila, ovary, histology.*

Akio Kondo, Eiko Chaki and Mitsuhiro Fukuda, Department of Biology, Faculty of Science, Toho University, 2-1, Miyama 2 chome, Funabashi-shi, Chiba, 274 Japan; 21 December 1992.

The golden silk spider, *Nephila clavata* L. Koch, is able to deposit egg masses twice (Kondo, 1988; Shimojana, 1971). Prior to the first oviposition, gravid females possess complicated ovaries whose lumina are expanded among mature eggs. After the second oviposition, the ovarian lumen of exhausted females is not closed and contains immature oocytes and yolk granule debris. In both cases, the basic architecture of the ovary is not clearly identified. In vigorous females immediately after first oviposition, the lumen of the ovary is completely closed and the ovarian epithelium protrudes many young oocytes into the body cavity. In this case the ovarian tubes elongate dorsally and ventrally to form flat cisternae, as if the lumina have been squeezed between mature eggs, already ovulated at the first oviposition, side by side (Kondo and Chaki, 1991).

Generally, however, the spiders have a pair of tubular ovaries or ring-like ovaries. The present study tries to clarify whether the cisternal architecture of the ovary of *N. clavata* is primarily or secondarily formed by pressure from mature eggs.

MATERIALS AND METHODS

Four female subadult and two adult *Nephila clavata* were collected in Funabashi, Central Japan, from late August to early September.

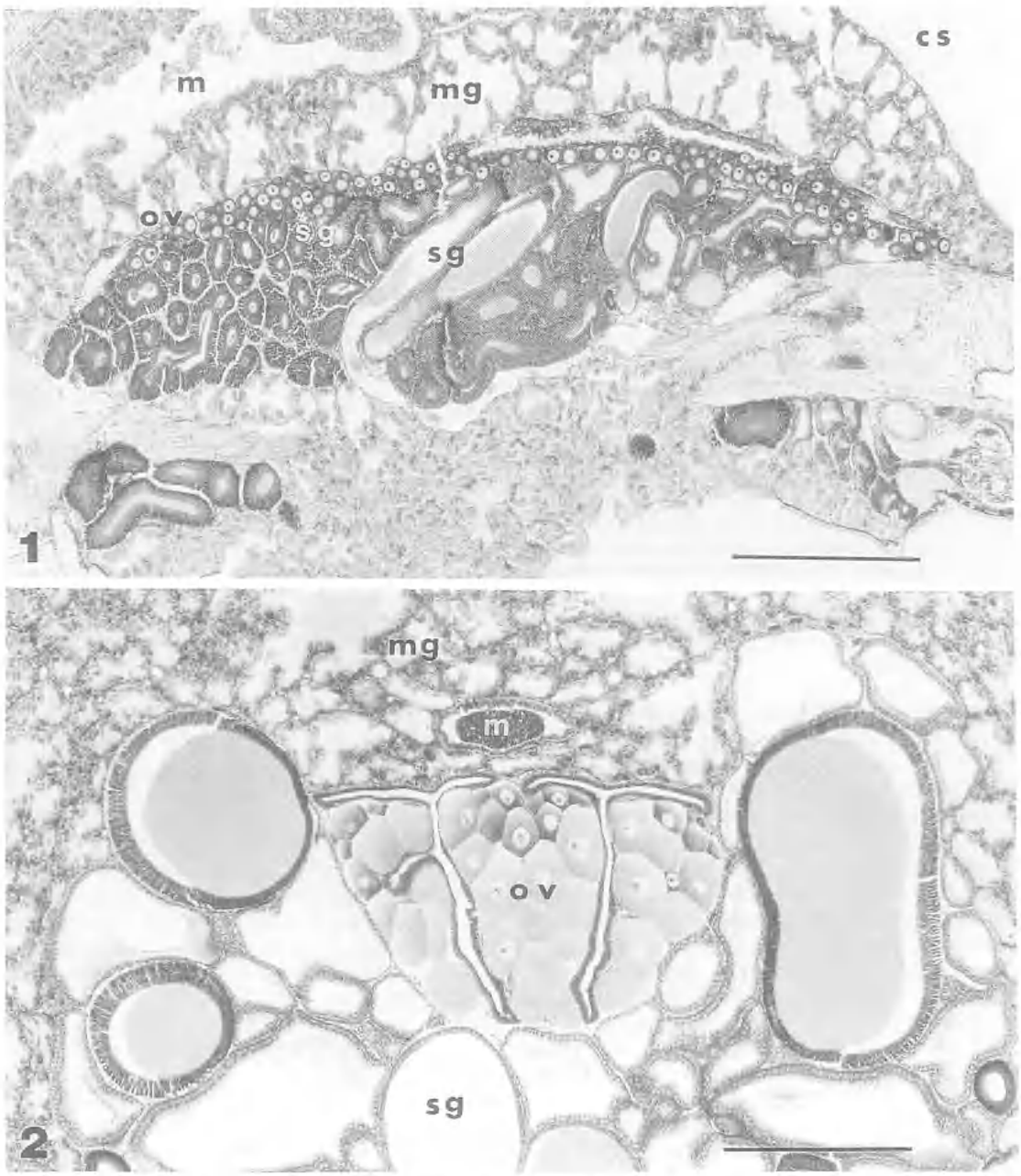
After removal of the cuticle, the entire body or the opisthosoma was fixed in FAA (formalin 5, ethanol 15, glacial acetic acid 1) for 5-21 hours, dehydrated in graded strength of ethanol, embedded in paraffin and sectioned at 6-10μm. Before sectioning, a cut surface of the sample containing mature eggs was treated with distilled water (Kondo, 1969). Serial paraffin sections were stained with Mayer's acid-haemalaum and eosin.

RESULTS

Subadults

A pair of ovaries was situated behind the book lung extending to the cloacal sac and surrounded by the midgut glands dorsally and by silk glands laterally and ventrally (Figs 1, 2). Although the ovarian tissue was divided in two at the anterior and posterior ends, the left and right ovaries were not separated from each other and formed single rod-shaped tissue for the most part.

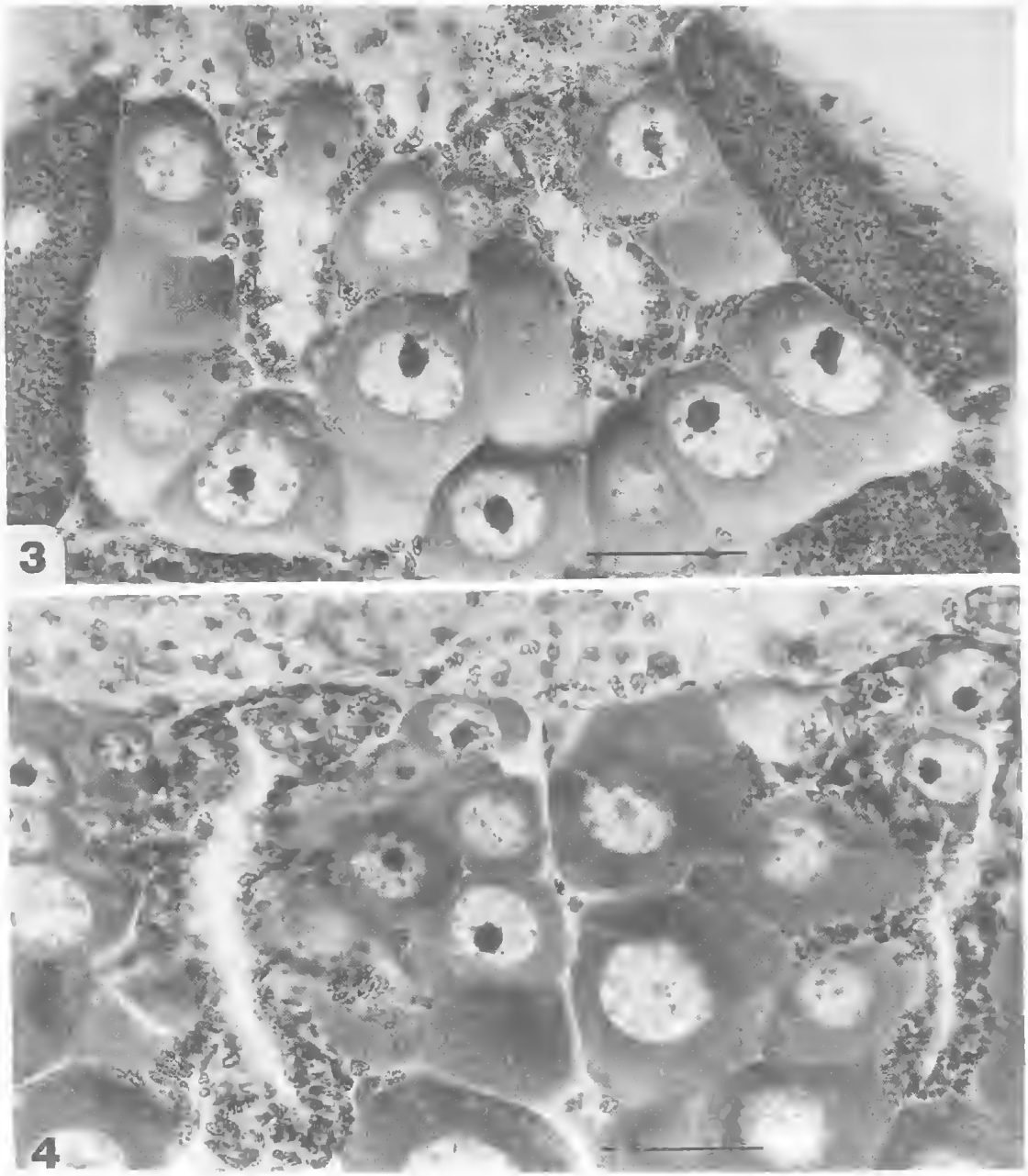
Maximum width and thickness of the ovarian tissue were 250μm and 150μm in a small subadult with cephalothorax 1.6 mm wide, 2.6 mm long, and 500μm and 220μm in a large subadult



FIGS 1, 2. 1. Longitudinal section of a large subadult.cs: cloacal sac, m: midgut, mg: midgut gland, ov: ovary, sg: silk gland. 2. Transversal section of a female immediately after final moulting. m: midgut, mg: midgut gland, ov:ovary, sg: silk gland. Scales: 0.5 mm.

whose cephalothorax was 2.8 mm and 4.2 mm respectively.

In transverse sections the ovarian tissue was trapezoidal. In a small subadult, two furrows lined with a loose cell layer penetrated from the upper side of the trapezoid into the ovarian tissue (Fig. 3). The loose cell layer may be the ovarian wall or the ovarian epithelium. Then the furrows seemed to be surrounded by a single layer of the oocytes. Most oocytes, whose cytoplasm was strongly basophilic, were cuboidal or polygonal and 40-50μm in diameter.

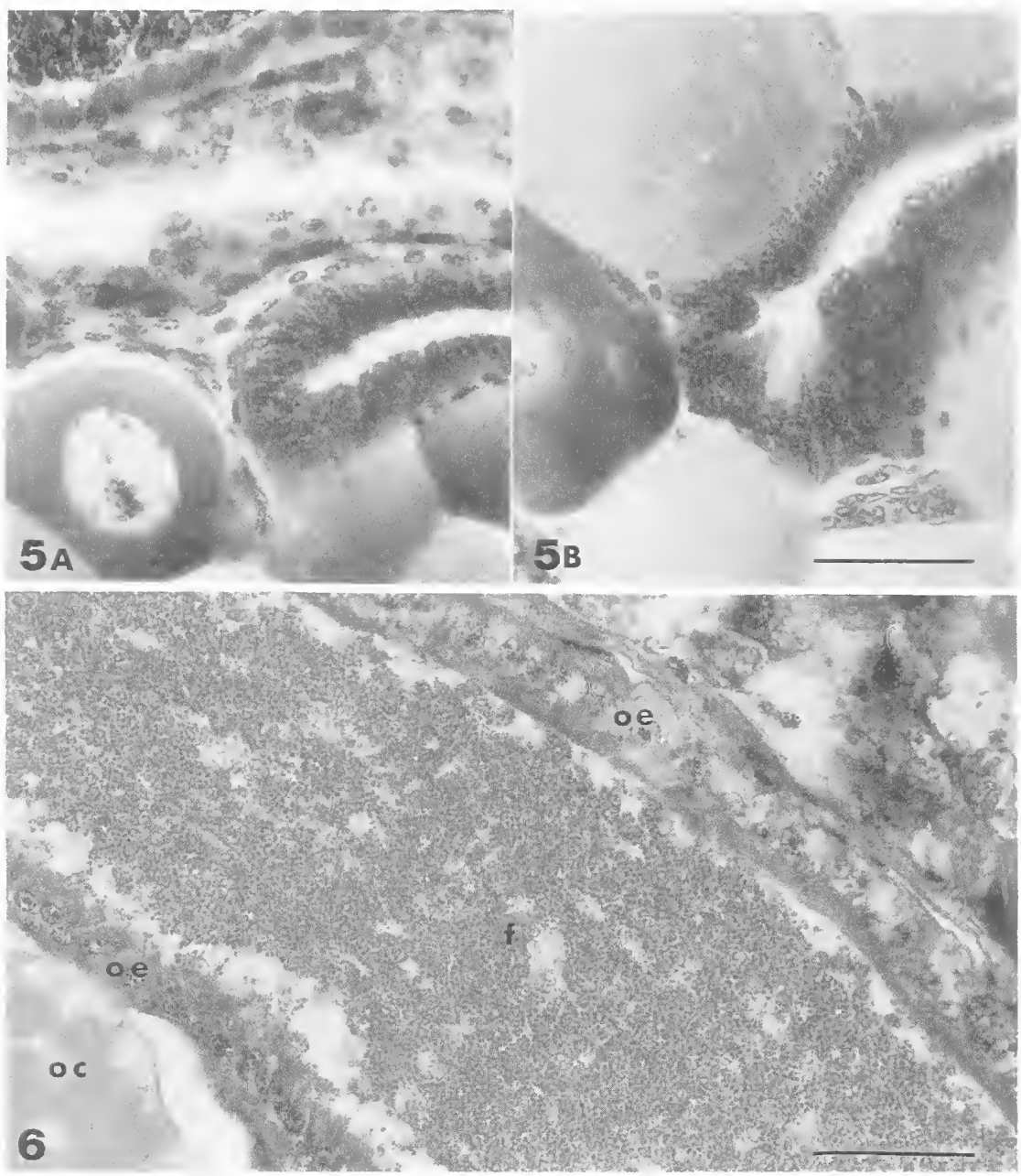


FIGS 3, 4. Transverse section of ovarian tissue in small subadult (3) and in large subadult (4). Scales: 50μm.

The spherical germinal vesicle was 25-35μm in diameter and contained an extremely basophilic and slightly eosinophilic nucleolus. Yolk granules had not formed. The vitelline body or Balbiani's yolk nucleus was not observed.

Each oocyte was connected with the ovarian wall through a short egg stalk or the funiculus. The cells constituting the ovarian wall were more or less columnar and had ellipsoidal nuclei in the basal part and vacuolated protoplasm in the distal part facing the presumptive lumen of the ovary.

In the large subadult, profiles of the oocytes closely resembled the oocytes in the small subadult, though they increased slightly in number



FIGS 5, 6. 5. Transverse section of ovary in female immediately after final moulting. A. Median dorsal part of ovary. B. Distal part of F-shaped lumen of ovary. 6. Lumen of ovary filled with eosinophilic fine granules in a gravid female. f: eosinophilic fine granules, oc: oocyte, oe: ovarian epithelium. Scales: 50μm.

and volume (Fig. 4). A prominent feature was the appearance of narrow lumina in the ovaries, while vacuolate cells in the ovarian wall remained in depth at both the anterior and posterior ends of the ovarian tissue.

ADULTS

In an adult presumably immediately after its final moult, the width of the entire ovaries was approximately 1.0 mm and the lumen of the ovary was F- or T-shaped, branching laterally (Fig. 2). The left and right ovarian epithelia were not

fused, but connected with the oviducts. Total number of oocytes counted in one female was 1,390 including the small oocytes. No oocytes were observed above the dorsal side of the horizontally developing lumina.

Oocytes reached a diameter of 170μm. Germinal vesicles were 40-60μm in diameter. The nucleolus was collapsed and dispersed into nucleoplasm. Cytoplasm of the oocyte was less basophilic (Fig. 2). The eosinophilic yolk granules were neither formed nor accumulated. The ovarian wall seemed to be a simple columnar or pseudostratified epithelium composed of slender, compactly arranged and extremely basophilic cells. Flat cells were lined up between the ovarian epithelium and the oocytes (Fig. 5).

In a gravid female whose ovaries reached 4.0 mm in width, the ovary contained many developing oocytes 380-460μm in diameter, and few immature oocytes. The developing oocytes were filled with eosinophilic yolk granules and had a germinal vesicle 50-60μm in diameter. The lumen of the ovary branches among the developing oocytes. The lumen of the ovary contained eosinophilic fine granules which were presumably a kind of cement substance used to hold the egg mass after oviposition (Fig. 6).

DISCUSSION

The formation of the ovary in *Nephila clavata* was examined from the early subadult stage. The small subadult employed was possibly a nymph of the 6th or 7th instar prior to the penultimate moult. In any case, at an early stage, the longitudinal ovarian walls arise as loose cell layers penetrating from the dorsal side of the ovarian tissue perpendicularly into the mass of the oocytes. The epithelial cells are vacuolated in their distal part and form a lumen which is I-shaped in transverse section. Then, the ovarian epithelium constructs flat rather than cylindrical cisternae.

By the final moult the lumina have been formed in the vacuolated portion of the ovarian epithelium. Immediately after the final moulting, while the oocytes increase in number and volume, a few branches of the lumen arise, mostly in the posterior half of the ovary, forming F- or T-shaped profiles in transverse sections. Simultaneously the oocytes grow and become less basophilic, perhaps due to a cytoplasmic increase. The loose cell layer in the small subadult transforms gradually into columnar epithelium composed of slender, compact and strongly basophilic cells by the final moult. Since the oocytes are connected with this epithelium through egg stalks, it seems to be the ovarian epithelium in the strict sense, though flat cells are aligned along the outside of this epithelium.

Subsequently the oocytes begin vitellogenesis and accumulate eosinophilic yolk granules in their cytoplasm. The lumina of the ovaries continues to branch amongst the oocytes and on the surface of the mass of the oocytes, and they are filled with eosinophilic fine granules which correspond to fine granules attaching to the surface of the chorion of the lycosid egg (Kondo, 1969), the spheres on the chorion (Humphreys, 1983, 1987) or cement substance of the egg mass (Kondo and Chaki, 1991).

In *N. clavata*, the ovarian epithelia of the left and right ovaries are not directly connected with each other, though in archaeid spiders they are connected through a bridge in the posterior portion of the ovaries to form a H-shaped organ (Traciuc and Legendre, 1970). Interstitial tissue, however, does not exist between the left and right ovaries, so the ovaries of *N. clavata* form a single rod-shaped organ. This rod-shaped structure was confirmed not only from both transverse and horizontal sections but also by dissection of the opisthosoma.

In conclusion, in *N. clavata* the basic architecture of the ovary is primarily composed of flat cisterna.

LITERATURE CITED

HUMPHREYS, W.F. 1983. The surface of spiders' eggs. Journal of Zoology, London 200: 303-316.

1987. The accoutrements of spiders' eggs (Araneae), with an exploration of their functional importance. Zoological Journal of the Linnean Society, London 89: 171-201.

KONDO, A. 1969. The fine structures of the early spider embryo. The Science Report of the Tokyo Kyoiku Daigaku, Section B No. 207: 47-67, pls 1-8.

1988. Effects of incubation temperature on the embryonic development and the oviposition in the silk spider, *Nephila clavata* L. Koch. Proceedings of Arthropodan Embryological Society of Japan No. 23: 21-22.

KONDO, A. & CHAKI, E. 1991. Histological studies on the ovaries of the golden silk spider, *Nephila clavata* L. Koch, before and after oviposition. Proceedings of Arthropodan Embryological Society of Japan No. 26: 9-10.

SHIMOJANA, M. 1971. Studies on the genus *Nephila* in Okinawa Island. (1) Studies on the life cycle of *Nephila clavata*. Biological Magazine Okinawa 7: 1-18 (In Japanese).

TRACIUC, E. & LEGENDRE, M.R. 1970. Données

anatomiques sur l'appareil genital femelle des Archaeidae (Araneides). Comptes Rendus Hebdomadaires des Séances de l'Academie des Sciences, Série D, Sciences Naturelles 270: 1918-1921.